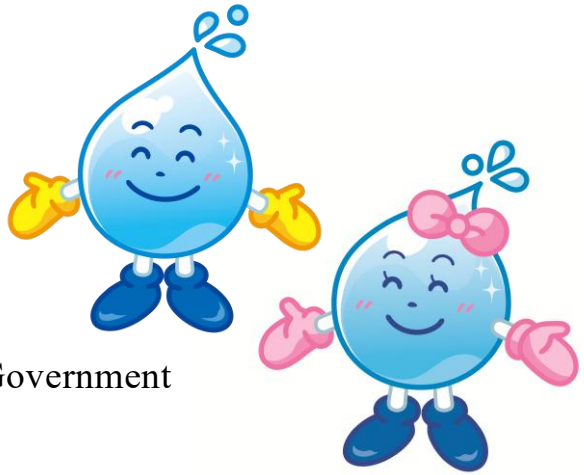
Prevention of Leakage in Tokyo

2026



Bureau of Waterworks, Tokyo Metropolitan Government

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1 Leakage Prevention

(1) Overview

The tap water used in Tokyo is primarily sourced from the Tone, Arakawa, and Tama river systems, which flow through the Tokyo metropolitan area.

The water (raw water) intake from these rivers, and other sources undergo water treatment processes, such as sedimentation, filtration, and disinfection, at purification plants. In addition, purification plants that source water from the Tone and Arakawa river systems have introduced advanced water treatment processes, including ozonation and biological activated carbon adsorption. Treated water (tap water) is supplied to customers through distribution pipes buried underground with pressure applied. During this process, water may escape from the distribution pipes and flow out onto the ground or into the ground. This is called the “leakage.”

The Bureau of Waterworks, Tokyo Metropolitan Government (“the Bureau of Waterworks”) possesses a daily water supply capacity of approximately 6.8 million m^3. However, due to the effects of climate change associated with global warming, rising temperatures, decreasing numbers of rainfall days, and increasing frequency of heavy rain are occurring. Japan's annual average temperature is already rising at a rate of 1.4°C per 100 years, and it is predicted to rise by as much as approximately 4.5°C by the end of the 21st century compared to the end of the 20th century. In the future, if climate change leads to a significant decrease in snowfall and an earlier melting season, river flows will decrease during the peak demand period for agricultural water, making it necessary to compensate with water from dams to a greater extent than ever before.

Considering these circumstances, in order to ensure a stable water supply for the capital, Tokyo, it is necessary not only to address current water demand but also to secure and stabilize water sources, while looking ahead to the impacts of future climate change, and to maximize its utilization.

Treated water is conveyed to water supplying stations and then distributed to individual households and businesses via water distribution pipes. These pipes consist of distribution mains and distribution sub-mains that branch off from the distribution mains. As of the end of FY 2025, the total length of distribution pipes laid throughout Tokyo



Figure 1: Site of a leakage Incident



Figure 2: Corroded Cast-Iron Pipe Causing Leakage

amounted to 27,639 km, equivalent to two-thirds of the Earth's circumference. In addition, service pipes branching off from these distribution sub-mains are installed in each household and business.

In addition to aging, buried pipes are constantly at risk of leakage due to the effects of earthquakes, differential ground settlement, corrosive soil, traffic loads, and various construction works.

Leakage not only leads to the loss of precious water resources but also poses a risk of secondary damage, such as poor water flow, road subsidence, and flooding of buildings. Therefore, the Bureau of Waterworks is implementing leakage prevention measures as a key initiative.

(2) Current Status of Leakage

In FY1992, Tokyo's annual leakage volume was approximately 183 million m^3, the leakage rate was 10.2% within the double-digit range; however, since FY 1993, the leakage rate has fallen to the single-digit range. In FY2025, with an annual water distribution volume of approximately 1.541 billion m^3, the leakage volume was approximately 60 million m^3, resulting in a leakage rate of 3.9%. (See Figure 3, Reference 1, and 2).

Most leakage occurs due to cracks, corrosion, and other deterioration resulting from the aging of service pipes managed by customers and distribution pipes managed by the Bureau of Waterworks. In FY 2025, the total number of repairs for leakage was 8,951; approximately 97% of them originated from service pipes, while the remaining approximately 3% originated from distribution pipes (See Reference 3).

Leakage can be broadly categorized into two types: surface leakage and underground leakage. Generally, surface leakage is addressed through immediate repairs (mobile work) and underground leakage through planned detection and repair (planned work). In FY 2025, there were 8,674 mobile works and 277 planned works (see Figure 4; for the number of leakage repairs by type and fiscal year, refer to Reference 4).

While surface leakage is easily detected because it is visible, underground leakage often continues for long periods because the leakage conditions cannot be directly observed.

Although leakage is repaired upon detection, new leaks develop gradually with time. This phenomenon is referred to as the "recurrence" of leakage (Figure 5). It is important to steadily implement leakage prevention measures that account for this repetition.

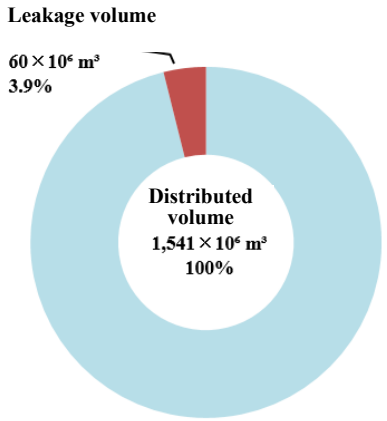


Figure 3: Water Distribution and Leakage volume for FY 2025

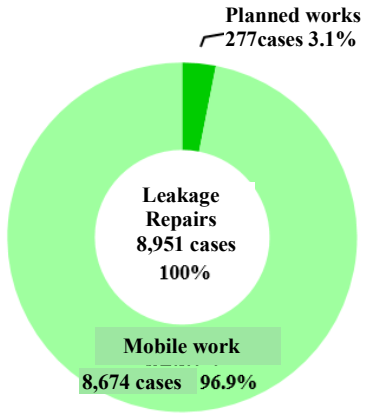


Figure 4: Comparison of Mobile and Planned Works (Number of Repairs in FY2025)

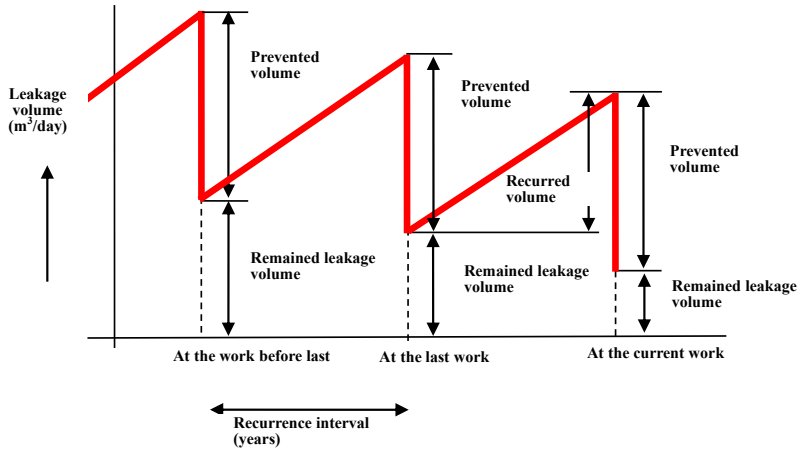


Figure 5: Recurrence of Leakage

2 Leakage Prevention Measures

(1) Framework for Preventing Leakage

The Bureau of Waterworks is implementing leakage prevention measures focused on three key pillars: “systematic replacement of distribution pipes and improvement of pipe materials,” “early detection and repair of leakage,” and “securing advanced leakage prevention techniques.”

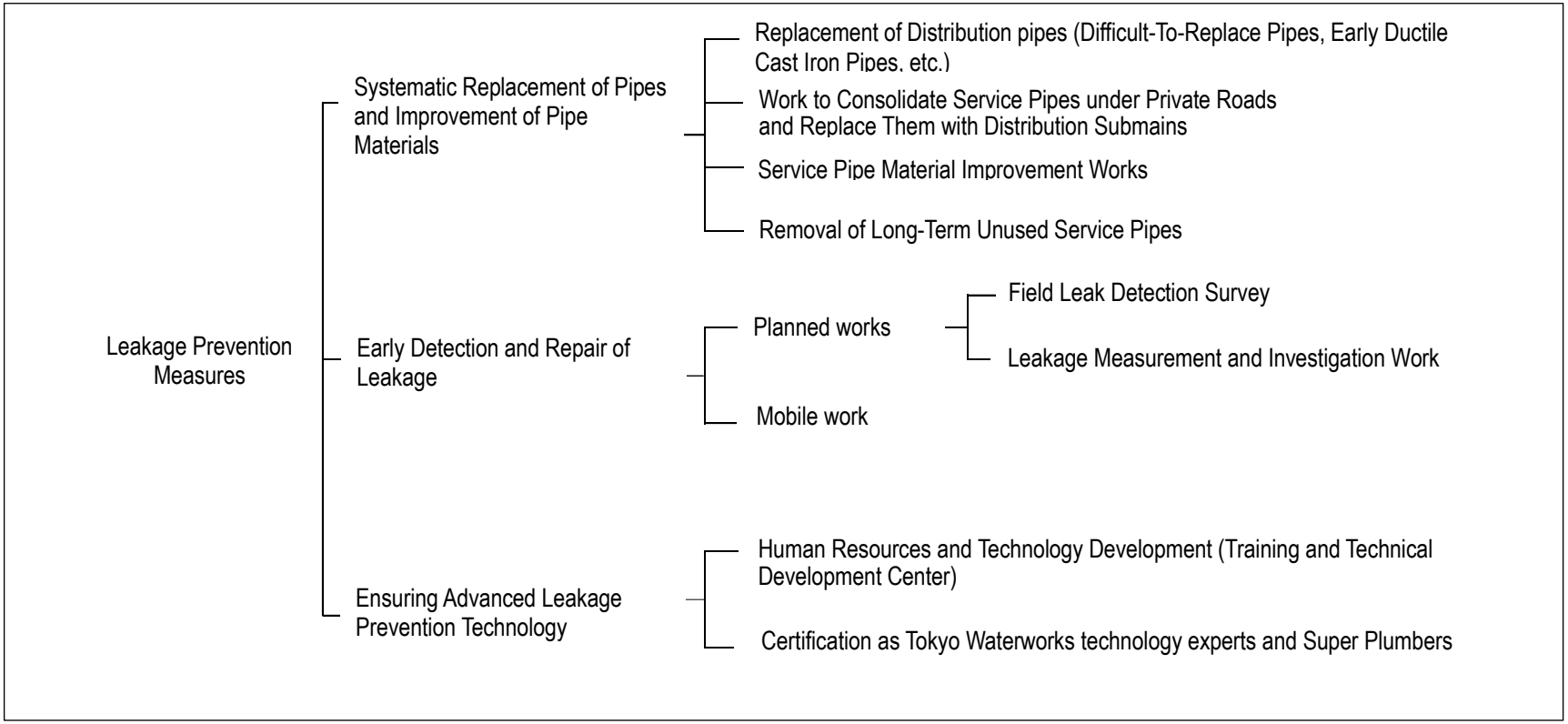


Figure 6: Schematic Diagram of Leakage Prevention Measures

A Systematic Replacement of Pipes and Improvement of Pipe Materials

(a) Replacement of Distribution pipes(Difficult-to-Replace Pipes, Early Ductile Cast Iron Pipes, and other pipes)

Since the total length of the distribution pipes is approximately 27,639 km, it is necessary to carry out their renewal in a continuous and systematic manner. Therefore, since the 1960s, the pipes which were made of high-grade cast iron and vulnerable to external impacts, have been gradually replaced with ductile cast iron pipes which are more resilient and have higher strength.

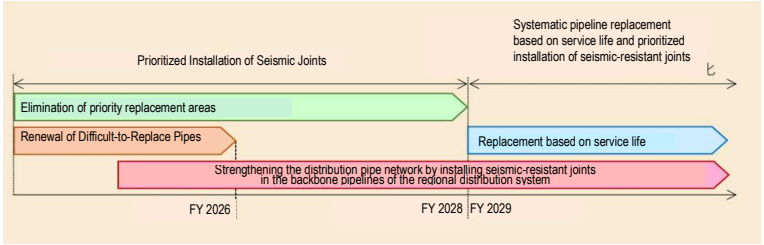


Figure 7: Procedure for Pipeline Replacement

However, in areas where construction is difficult, such as locations with a high concentration of underground utilities, there are still numerous pipes that are difficult to replace, as they were installed long ago and are at risk of leak. In addition, pipes with a high risk of leakage, such as early ductile cast iron pipes and steel pipes without polyethylene sleeves, still remain. While the urgent threat of an earthquake directly beneath the capital has been highlighted, the Bureau of Waterworks has been proceeding with the installation of seismic-resistant joints on distribution pipes, including these pipelines. By the end of FY 2025, the Bureau of Waterworks aims to increase the rate of seismic-resistant joint installation to 54% and has largely completed the installation of such joints on supply routes to critical facilities. To further mitigate the damage caused by water outages more effectively, the Bureau of Waterworks is prioritizing the replacement of pipes difficult to replace and the elimination of areas designated as high-priority for replacement, as well as the installation of seismic-resistant joints on the backbone pipelines of the regional distribution system located upstream of the distribution sub-main networks.

The replacement of the distribution pipes is proceeding as follows.

a FY 1973 ~ Replacement of difficult-to-replace pipes comprising low-strength unlined cast iron pipes and aging steel pipes

b FY 2005 ~ Replacement of early ductile cast iron pipes containing straight pipes made of ductile iron and special-shaped pipes made of high-grade cast iron

c FY 2007 ~ Replacement of non-seismic-resistant pipe joints installed along supply routes to critical facilities such as capital's central agencies, emergency medical facilities, evacuation shelters, and major train stations

d FY 2013 ~ Replacement of non-seismic-resistant pipe joints installed in areas where the Bureau of Waterworks damage projection anticipates a water

supply disruption rate exceeding 50% in the event of an earthquake (priority replacement areas)

e FY 2018 ~ Replacement of steel pipes without polyethylene sleeves

f FY 2026 ~ Replacement of non-seismic-resistant joints in the backbone pipelines of the regional distribution system located upstream of the distribution sub-main network

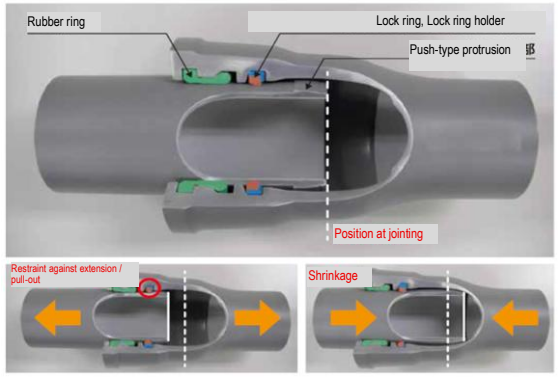


Figure 8: Seismic-Resistant Joint Structure- A structure designed to prevent the joints from separating even during an earthquake (Left: Normal conditions; Right: During an earthquake)

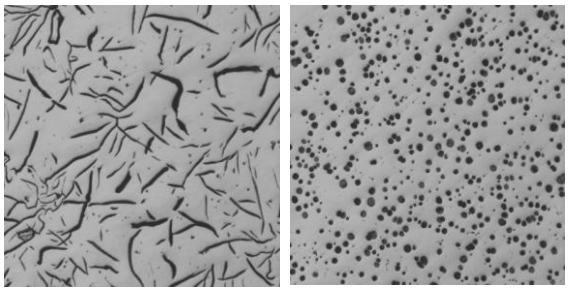


Figure 9: Microstructure of Cast Iron (Left: High-grade cast iron; Right: Ductile cast iron)

(b) Development of Service Pipes on Private Roads

In some private roads, multiple service pipes are laid over long distances, which is one of the major causes of leakage and poor water flow. Therefore, since 1994, service pipes have been reorganized and consolidated in private roads where three or more pipes are installed, in view of maintaining water pressure and preventing leakage. Since then, the replacement has been implemented by gradually easing the eligibility requirements; however, during the Great East Japan Earthquake, many of the leakage incidents in Tokyo were caused by polyvinyl chloride service pipes on private roads. Consequently, seismic-resistant distribution pipes are being installed and service pipes are being replaced with stainless steel pipes on all private roads, totaling approximately 2,600 km.

In addition, drain valves with the same function as fire hydrants are installed at the ends of distribution sub-mains, so that they can be used for emergency water supply in the event of an earthquake or for initial firefighting in the event of a fire.

The application requirements for distribution sub-mains in this program have been expanded as follows.

a FY 1994 ~ Private roads with three or more service pipes installed

b FY 2007 ~ Private roads with three or more service pipes installed, or with 15 or more water meters installed

c FY 2008 ~ Private roads with three or more service pipes installed, or with 10 or more water meters installed

d FY 2012 ~ Private roads with three or more meters installed

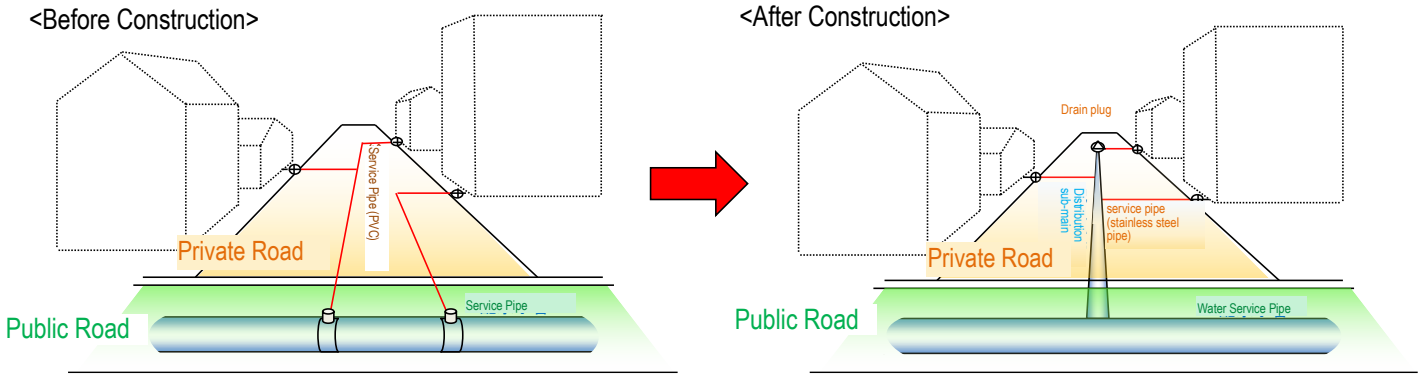


Figure 10: Service pipes Development on Private Roads

Furthermore, since FY 2012, for private roads with two or fewer water meters, private road stainless steel conversion works have been carried out to replace old, deteriorated polyvinyl chloride pipes and similar materials with stainless steel pipes, thereby further improving the seismic resistance of service pipes within private roads. Furthermore, since FY 2026, as part of the development of service pipes within private roads, replacement of existing polyvinyl chloride service pipes with stainless steel pipes has been carried out even in cases where new distribution pipes cannot be installed, such as when landowner consent cannot be obtained.

(c) Material Improvement Work for Service Pipes (Replacement of Service Pipes)

Most leakage occurs in old, deteriorated service pipes, which account for approximately 97% of all leakage repair cases (See Reference 3). Therefore, proactive prevention of leakage in service pipes is extremely effective for reducing leakage. The Bureau of Waterworks previously used lead pipes, which were easy to install beneath roads. However, because lead is weak and prone to corrosion, it was a major cause of leakage.

Consequently, since FY 1980, lead pipes have no longer been used for new service pipes installed beneath roads; instead, stainless steel pipes with superior strength and corrosion resistance have been adopted. Subsequently, with the objective of reducing leakage, stainless steel pipes have been gradually installed in the following service pipes.

a FY 1982 ~ Replacement of lead service pipes branching off from the main routes when replacing old distribution pipes and pipes prone to frequent leakage with ductile iron pipes

b FY 1983 ~ Replacement of lead service pipes branching off from distribution sub-mains already made of ductile cast iron in sections identified through planned works as having much leakage volume

c FY 1984 ~ Replacement of lead service pipes branching off from distribution sub-mains in all distribution sub-main construction works

d FY 1985 ~ Replacement of lead service pipes with severe material degradation during leakage repairs

In a ministerial ordinance issued by the Ministry of the Environment (formerly the Ministry of Health, Labor, and Welfare) regarding water quality criteria, the water quality criterion for lead was strengthened in 1992 (quality criterion value: 0.05 mg/L), and a long-term target value to be achieved 10 years later (water quality target value: 0.01 mg/L) was also specified. Consequently, since FY 1992, the use of lead service pipes, except for repairs of leakage, has been prohibited.

Furthermore, to actively promote the switch to stainless steel, the use of lead service pipes was completely prohibited from FY 1995. From FY 1998, corrugated stainless steel pipes, superior in terms of constructability and seismic resistance, were adopted. At the same time, the extent of material quality improvement was expanded from the branch points of the distribution sub-mains to the first shut-off valve on residential land, to now include the water meter on residential land. Since then, rigid polyvinyl chloride pipes have been used for service pipes from the first shut-off valve on residential land to the water meter.

Since 1998, the plan to eliminate lead service pipes to the point of the meter on residential land was formulated for all service pipes. By the end of FY 2006, the replacement of lead service pipes on private roads or to the point of the meter on residential land was almost completed.

Please note that there are still a few lead service pipes remaining on private roads or on residential land that were not replaced during previous replacement works. For these pipes, additional surveys are being conducted as part of the planning process for FY 2007 and beyond, allowing for their replacement as discovered, after obtaining consent from customers.



Figure 11: Water Leak from Lead Water Service Pipe

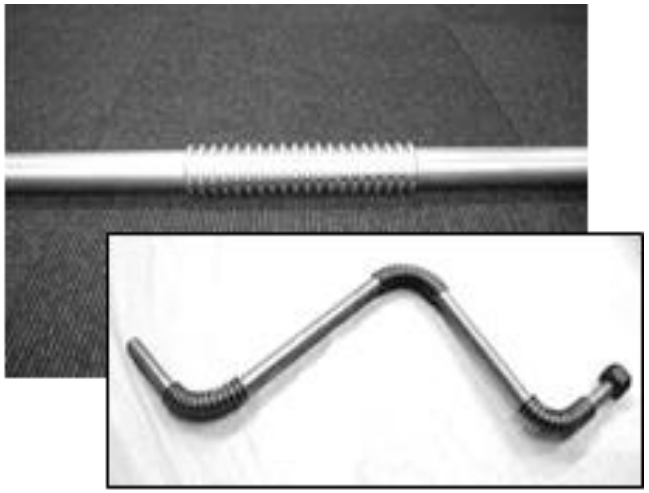


Figure 12: Corrugated Stainless Steel Pipe

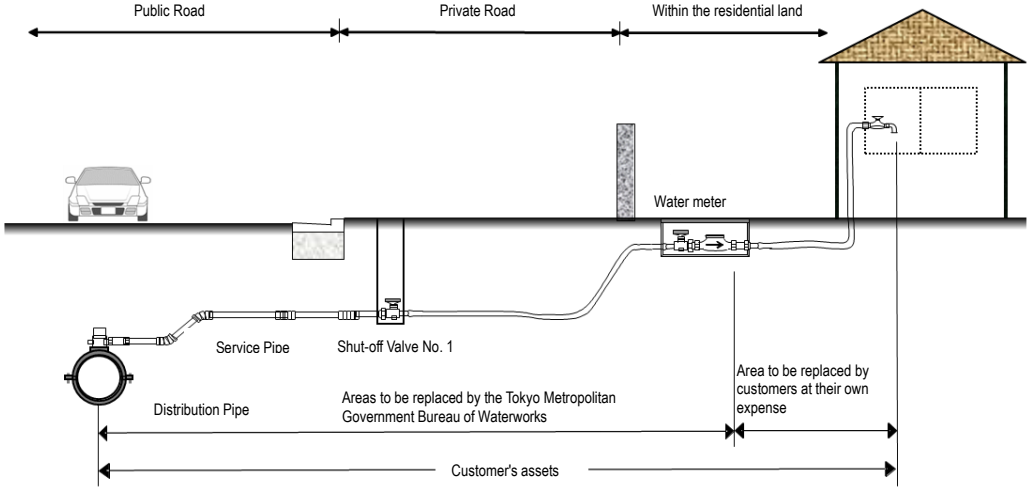


Figure 13: Improvement of Service Pipe Materials

(d) Cleanup of Long-Term Unused Service Pipes

More than 90 percent of leakage incidents in Tokyo occur in the service pipes delivering water to individual households and other customers. In vacant homes, in particular, service pipes that are not properly maintained are often left unused for long periods, leading to delays in detecting leakage. If such long-unused service pipes are not properly managed, they not only result in the loss of precious water but can also lead to secondary damage, such as road subsidence. Furthermore, there is concern that if a leakage occurs during a disaster, they could hinder rapid recovery efforts.

In principle, customers are responsible for removing service pipes not expected to be used.

However, from the perspective of reducing the risk of leakage and optimizing the water supply environment, the Bureau of Waterworks has been implementing a program from FY 2021 to 2025 regarding long-term unused service pipes branching off from distribution mains that have been retrofitted with seismic-resistant joints and that have been out of service for five years or more, to remove them upon obtaining customer consent.

From FY 2026, such works shall be proceeded with confirming the customers' preferences as well as concurrently with distribution main replacement works.



Figure 14: Water service pipe leak (seepage into the pavement)



Figure 15: Water service pipe with the water meter removed for a long time



Figure 16: Service pipes left as is without any expected use

B Early Detection and Repair of Leakage

Underground leakage gradually flows to the surface. To minimize damage caused by leakage, it is important to detect and repair such leakage promptly. Therefore, the Bureau of Waterworks carries out both Planned and mobile works, working day and night to prevent leakage.

Distribution pipes are maintained by the Bureau of Waterworks as part of the water supply infrastructure. On the other hand, since service pipes are the customer's own assets, customers are responsible for their maintenance and management. However, to ensure the effective use of precious water resources and to prevent secondary damage such as poor water flow or road subsidence, repairs are, in principle, carried out at the expense of the Bureau of Waterworks for pipes with a meter diameter of 40 mm or less, from the distribution sub-main to the water meter on the customer’s property, and for pipes with a meter diameter of 50 mm or more, within a one-meter radius from the road boundary.

(a) Planned Work

Planned work involves dividing the network of buried distribution sub-mains into sections of a certain length, managing each section as a single district, and systematically conducting leakage detection surveys in each district to address underground leakage. Planned work includes field leakage detection survey and leakage measurement and investigation work. In wards, Staff of the Bureau of Waterworks and Tokyo Water Co., Ltd., a policy partner organization of the Bureau of Waterworks, collaborate to systematically conduct these leakage inspections, and most of the leaks detected are repaired by their contractors.

In the Tama district (26 municipalities) leakage detection surveys were previously conducted by each municipality. Currently, Tokyo Water Co., Ltd. Conducts field leakage detection surveys ---house-to-house inspections using time-integral type leakage detectors--- and most of the leaks detected are repaired by contractors.

a Field Leakage Detection Survey

The field leakage detection surveys are conducted on a district-by-district basis. They include house-to-house inspections, in which a leakage sound detection bar (see Figure 21) is placed against every water meter in a district except for sub-meters to check for leakage, as well as route inspections, in which the pickup of an electronic leakage detector (see Figure 22) is placed against the road surface during nighttime hours with low traffic volume to inspect and specify locations of leakage.

The selection of districts for field leakage detection surveys is based on past performance records and the occurrence of leakage in the previous fiscal year.

Since FY 2003, time-integral-type leakage detectors (see Figure 26) have been used to screen for leakage. Since FY 2024, multi-point correlation leakage detectors (see Figure 28) have also been used for this purpose. When leakage is suspected, the location of the leakage is specified using the acoustic leakage sound detection method. Note that, since FY 2003, part of the field leakage detection survey work has been outsourced to Tokyo Water Co., Ltd.

b **Leakage Measurement and Investigation Work**

In the event of an earthquake, it is important to accurately understand the flow status from the distribution mains to the sub-mains in order to reduce water supply disruptions and ensure the rapid restoration of water supply facilities. If the connection pipes branching from the distribution mains remain functional, water supply routes can be secured by bypassing distribution sub-mains damaged by the earthquake, allowing the water-supplied area to be expanded from those routes.

Leakage Measurement and Investigation Work have been conducted since FY 2010 for purposes such as confirming water outages, performing drainage operations, and monitoring leakage trends, while keeping in mind the need to secure water supply routes for early service restoration in the event of an earthquake. First, leakage volume is measured in each area using the Minimum Night Flow Measurement Method and a minimum flow measurement device. During the measurement, in areas with high leakage volumes, leaking pipeline sections are identified. Water flow is then sequentially shut off along each section. While monitoring changes in flow rate with the minimum flow measurement device, pipeline sections suspected of leakage are isolated, so that the water-supplied area can be expanded.

This work also serves as practical training. By carrying out water-flow control operations and leakage detection surveys based on the leakage volumes measured in each area, it becomes possible to perform leakage prevention work efficiently and effectively.

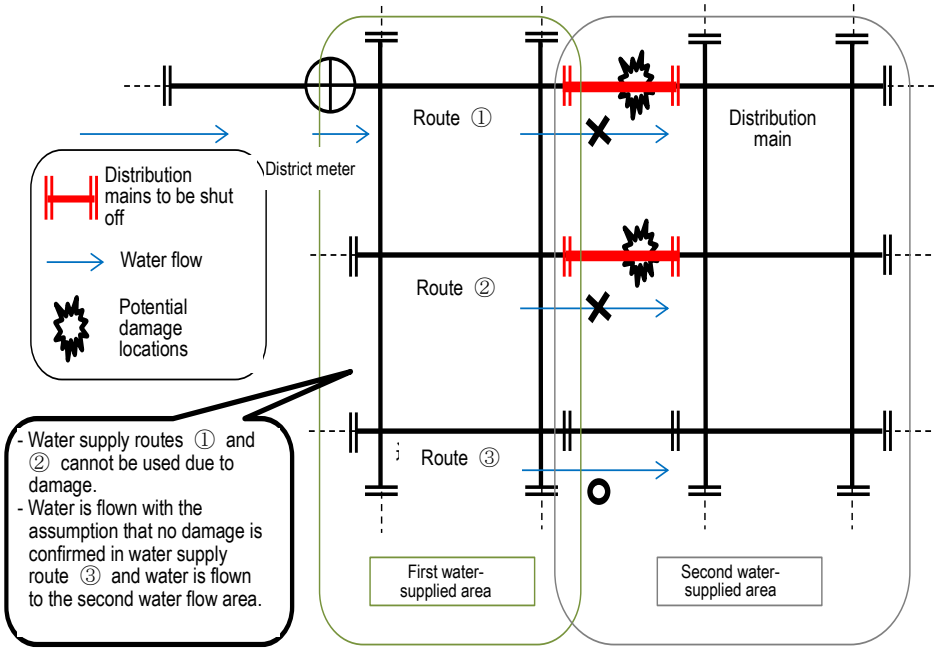


Figure 17: Leakage Measurement and Investigation Work

(b) Mobile work

Mobile work refers to the immediate repair, in principle, of surface leaks discovered through reports from customers or other sources. In the ward, staff at each branch office, Waterworks Emergency Services Unit, and contractors are each on standby 24 hours a day to address leakage.

In addition, in the Tama district (26 municipalities) staff at the Water Supply Management Offices and Water Supply Offices (four offices), which are the Bureau of Waterworks' on-site management offices, as well as employees of Tokyo Water Co., Ltd. and contractors are each on standby 24 hours a day to respond to leakage.

* Of the four on-site management offices, the Akiruno Water Supply Office has outsourced the management and operation of multiple functions and facilities to Tokyo Water Co., Ltd. from FY 2025.

C Ensuring Advanced Leakage Prevention Techniques

The Bureau of Waterworks faces two major challenges: maintaining a low leakage rate and dealing with the mass retirement of veteran staff. In this situation, in order to implement leakage prevention measures efficiently and reliably, it is necessary to carry out training to pass on various leakage prevention expertise, as well as to develop new technologies and foster human resources. Therefore, the following two initiatives are being implemented.

(a) Initiatives in Human Resource Fostering and Technical Development (Training and Technical Development Center)

The Training and Technical Development Center, established in 2005, and the Training and Technical Development Sections work together to ensure that the Bureau of Waterworks continues to provide customers with a stable supply of safe and delicious water for years to come. The center is dedicated to passing on technical expertise, enhancing employee skills, and conducting training and development programs designed to effectively address diverse needs.

For example, the pipeline testing facility is equipped with various experimental and verification facilities designed primarily to resolve problems related to pipelines, providing a training environment close to actual site conditions. These facilities are used not only for training staff of the Bureau of Waterworks but also for training programs offered to neighboring water utilities and overseas water utilities.



Figure 18: Training in leakage prevention techniques

(b) Initiatives Based on the Certification of Tokyo Waterworks Technical Experts and Super Plumbers

Currently, many veteran staff with experience-based technical expertise are nearing retirement across various departments of the Bureau of Waterworks, making the transfer of technical expertise a pressing challenge in leakage prevention operations.

Therefore, the "Tokyo Waterworks Technical Expert System" was established to have veteran employees serve as training leaders and instruct junior staff. Training in the leakage prevention techniques is also provided at the Training and Technical Development Center.

Furthermore, by recording accumulated tacit knowledge in an easy-to-understand video format and posting it on a shared network so that all employees can access it (as a "knowledge bank"), efforts are being made to enhance the transfer of leakage prevention techniques.

In addition, the Bureau of Waterworks is working to maintain and transfer plumbing skills, not only among its own staff but also among contractors engaged in distribution main construction, by certifying particularly outstanding plumbers as "Super Plumbers" with the aim of improving overall plumbing skills and motivation.

(2) Leakage Prevention Construction System

After completing leakage repairs and material improvement work on service pipes, the Bureau of Waterworks performs the following processes using its leakage prevention construction system.

A Receiving requests for leakage repairs, and managing work progress records

B Calculating construction costs for leakage repairs, material improvement works, and related work.

C Compiling actual data on causes of leakage and repair works

The various data processed by this system are used for formulating long-term plans, calculating budgets for subsequent fiscal years, selecting target areas for planned work, and compiling leakage repair cases. As such, the leakage prevention construction system plays a vital role in carrying out effective leakage prevention work.

3 Methods of Leakage Detection

Currently, leakage detection surveys are conducted using the following two main approaches. The first is the "Minimum Night Flow Measurement Method," in which survey districts are systematically selected based on the survey cycle and other factors, routes requiring leakage detection surveys are identified in advance, and leakage volumes are measured. The second approach involves detecting the presence of leaks through leakage sounds and pinpointing their locations using methods and equipment such as acoustic leakage sound detection, correlative leakage detection, time-integral-type leakage detectors, and multi-point correlation leakage detectors.

(1) Minimum Night Flow Measurement Method

The Minimum Night Flow Measurement Method measures leakage volume focusing on the occurrence of periods during the late-night hours when no legitimate water consumption at all (no-use period) within a district.

First, close the gate valves surrounding the district to be surveyed to ensure that no water flows in or out from sources other than the district meter. Next, measure the flow entering the district via the minimum flow measurement device installed on the district meter (see Figure 20). Then, the minimum flow recorded during the no-use period is regarded as the leakage volume.

* The minimum flow measurement device was jointly developed by the Bureau of Waterworks and a private-sector company.

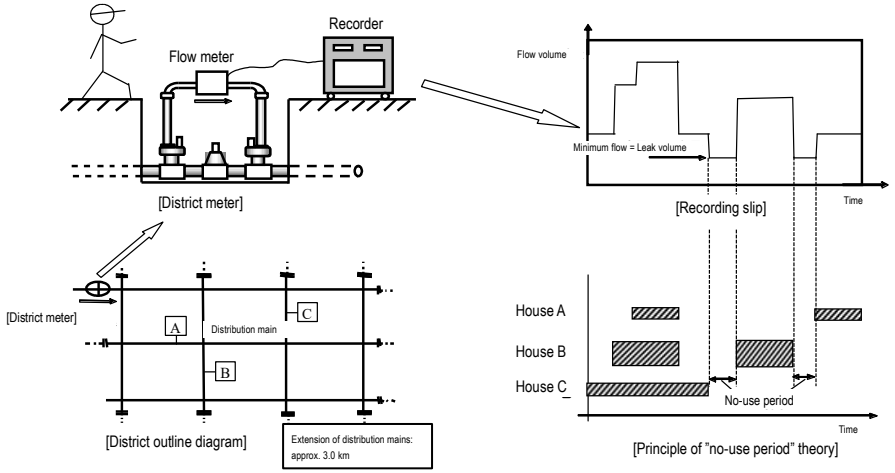


Figure 19: Principle of the Minimum Night Flow Measurement Method



Figure 20: Minimum Flow Measurement Device

(2) Acoustic Leakage Sound Detection Method

The acoustic leakage sound detection method uses a leakage sound detection bar or an electronic leakage detector to detect leakage sounds.

A leakage sound detection bar is used to listen to leakage sounds transmitted through the pipe. The operator places the tip of the metal bar against a water meter, gate valve, fire hydrant, or other equipment, then pressing his ear against the listening chamber attached to the other end of the bar to detect leakage sounds propagating along the pipe (see Figure 21). However, the leakage sound detection bar is primarily used to detect the presence of leakage in the immediate vicinity; it cannot detect the exact location of the leakage.

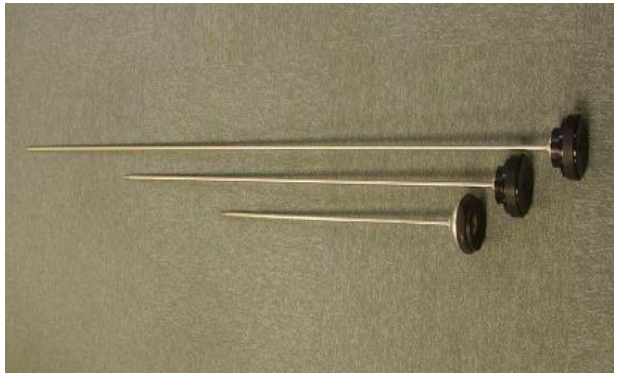


Figure 21: Leakage Sound Detection Bars

An electronic leakage detector is a device that uses a "pickup", a sensor that converts the leaking sound into an electrical signal, placed on the ground surface. And leaking sound propagating along the ground is amplified by a built-in amplifier in the pickup and can be listened through headphones (see Figure 22). Furthermore, by moving the pickup sequentially across the ground, the leaking sound is heard loudest directly above the leakage location, allowing the leakage location to be specified.

Among the sounds that can be detected using leakage sound detection bars or electronic leakage detectors, there are some noises that sound very similar to the leaking sound ("pseudo sounds").

Therefore, distinguishing leaking sounds from other sounds requires skilled technique.

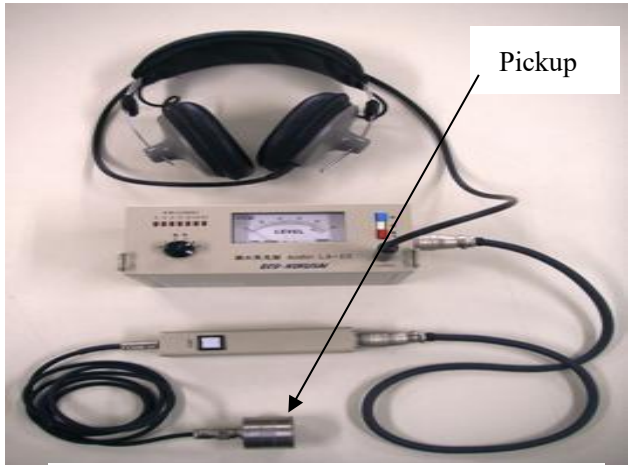


Figure 22: An Electronic Leakage Detector

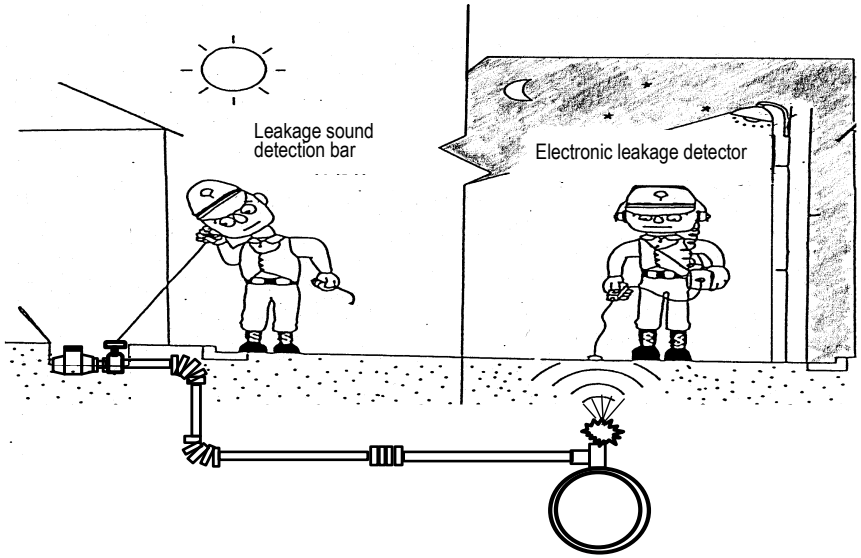


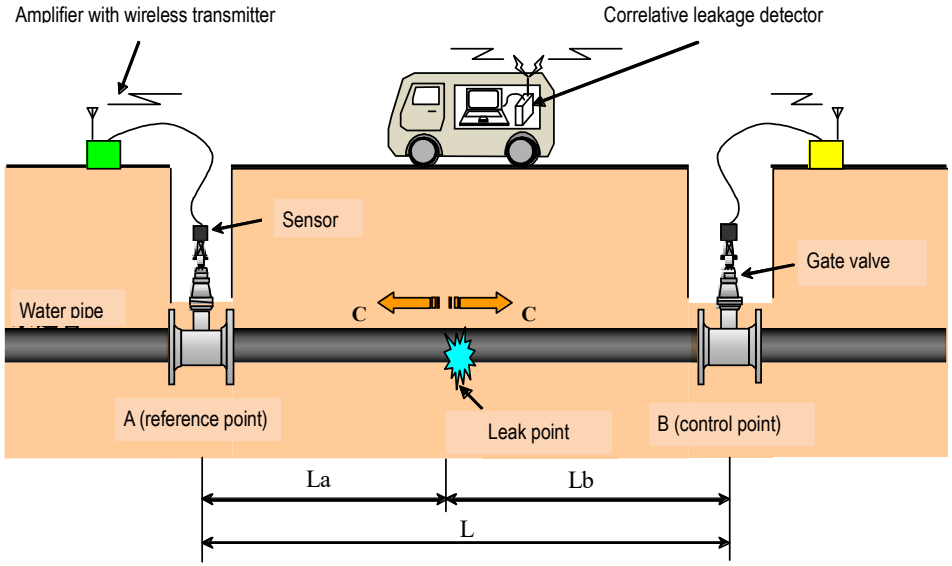
Figure 23: Leakage detection using the listening method

(3) Correlative leakage detection method

The correlative leakage detection method is the technique to detect the location of leakage using a correlative leakage detector (consisting of a correlator, detector [sensor], amplifier, radio transmitter, and other devices). Since it detects leakage sounds directly from the pipeline itself, it has the advantage of allowing inspections to be carried out without being affected by urban noise, including vehicle traffic, or by the burial depth of the pipeline.

First, sensors are installed at two auxiliary facilities located at two points on the pipeline, positioned on either side of the section where leakage is expected such as gate valves and fire hydrants. A correlator is then used to measure the time difference between the arrival of the leakage sound at the two sensors. Based on this difference in leakage sound arrival time, the distance between the two sensors, and the speed at which the leakage sound propagates through the water pipeline, the leakage location is calculated and specified.

* The correlation leakage detector was jointly developed by the Bureau of Waterworks and a private-sector company.



$La = (L - Tm \cdot C) / 2$

Tm : Leakage sound propagation time
C : Leakage sound propagation velocity
L : Distance between two points (A and B)

Figure 24: Principle of the Correlative leakage detection method

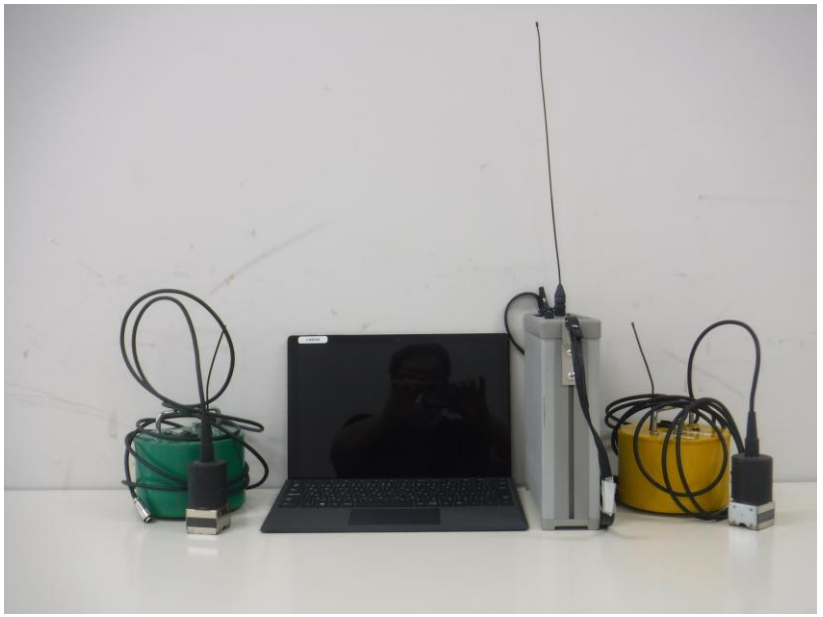


Figure 25: A Correlative Leakage Detector

(4) Time-Integral-Type Leakage Detector

The time-integral-type leakage detector is a device that determines the presence or absence of a leakage by utilizing the continuous nature of leakage sounds.

This device determines whether leakage is present by placing a sensor against the exposed section of the service pipe in each customer's water meter box and measuring sound transmitted through the pipe for a set period of time (approximately 1 to 5 seconds).

This device is not easily affected by intermittent sounds from water use or the sound from passing vehicles transmitted through the ground, and it does not require specialized skills to operate.

*The time integral type leakage detector was jointly developed by the Bureau of Waterworks and a private-sector company.

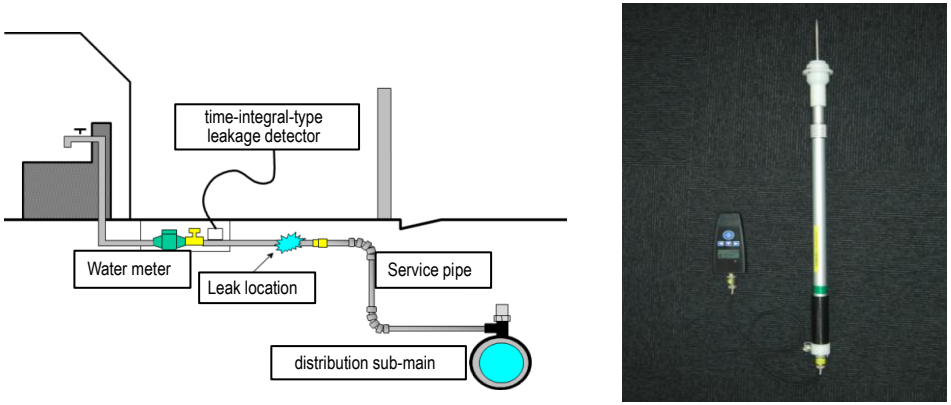


Figure 26: Time Integral Type Leakage Detector

(5) Transmission-Type Leakage Detector

The transmission-type leakage detector is a device that injects helium, an inert gas, into a water pipe and uses ground surface detectors to detect the helium that leaks from a leak in the pipe and permeates through the ground, thereby specifying the location of the leakage.

Since this detection method differs from the acoustic leakage sound detection method and the correlative leakage detection method, it does not rely on leakage sounds. It can therefore detect even minor leakage that produces sounds too faint to detect, as well as leakage in pipes buried at significant depths, such as large-diameter pipes (distribution mains).

* The transmission-type leakage detector was jointly developed by the Bureau of Waterworks and a private-sector company.

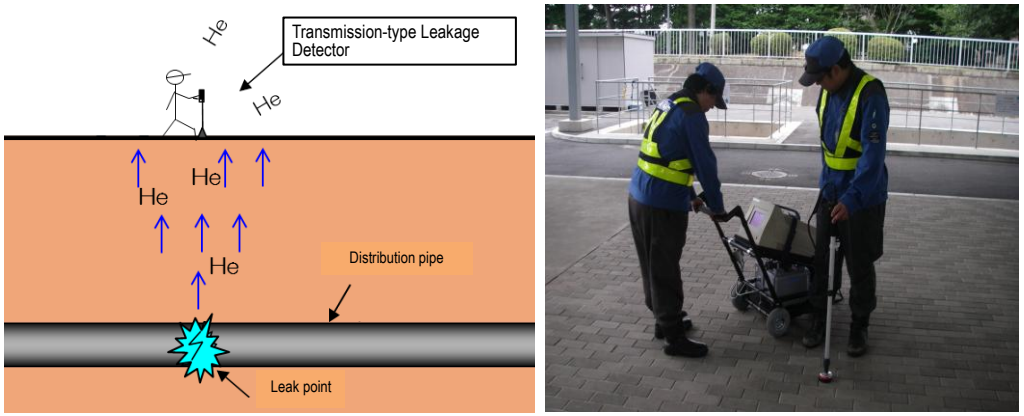


Figure 27: Transmission-Type Leak Detector

(6) Multi-Point Correlation Leakage Detector

The multi-point correlation leakage detector is a device that detects leakage by using loggers installed at multiple appurtenances along distribution mains, such as gate valves and fire hydrants. The loggers detect and analyze the sounds propagating along the pipes.

This device can determine the presence or absence of leakage even on routes where acoustic detection is difficult to use, such as in deeply buried pipes or pipes located under railway tracks, and can survey a wide area at once. It is also less affected by ambient noise and does not require specialized skills to operate.

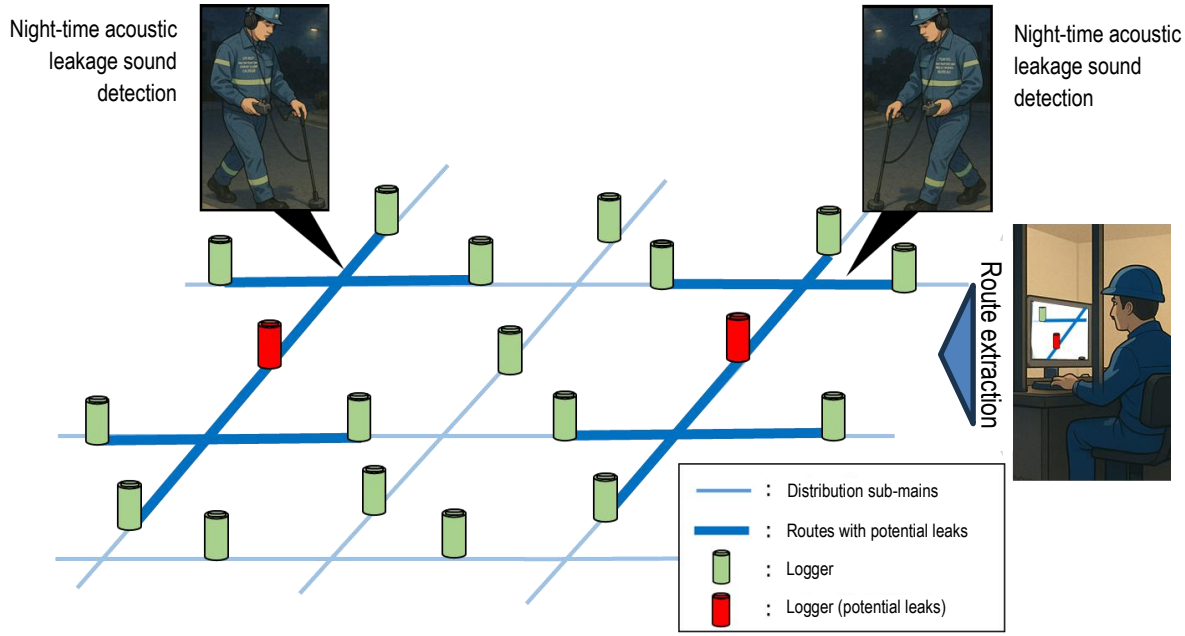


Figure 28: Multi-Point Correlation Leakage Detector

*** This image was generated by AI**

(7) Other Leakage Detection Methods

Leakage detection requires not only techniques for detecting leakage itself, but also techniques for locating buried pipes and water quality testing techniques for determining whether water flowing from the ground is tap water. To locate buried pipes, metal pipe locators (see Figure 29) and acoustic signal transmitters (see Figure 30) are used.

In addition, determining whether the water is tap water involves simple water quality tests, using devices such as thermometers, residual chlorine meters, pH meters, and conductivity meters, as well as detailed water quality tests to determine the presence or absence of trihalomethanes.



Figure 29: Metal Pipe Locator



Figure 30: Acoustic Signal Transmitters

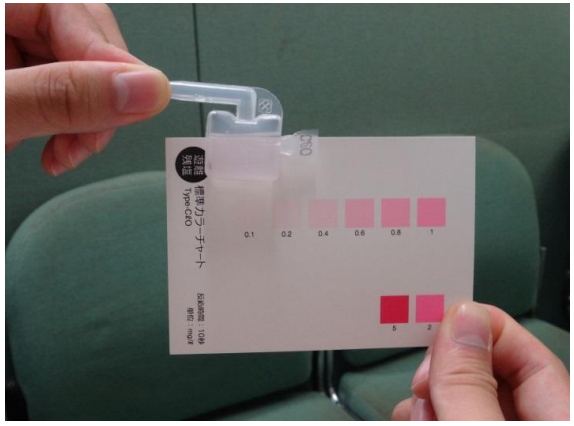


Figure 31: Simple Water Quality Test Kit

(for measuring free residual chlorine)

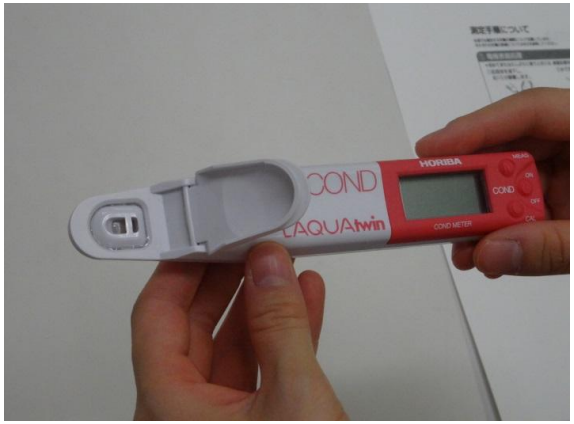
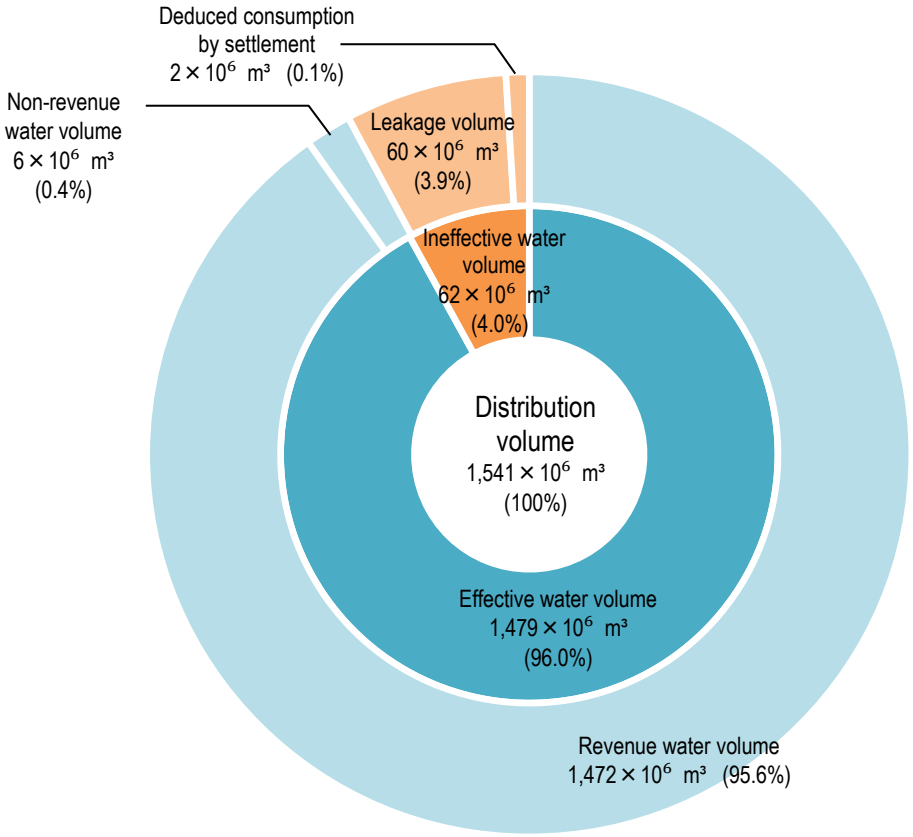


Figure 32: Conductivity Meter

4. References



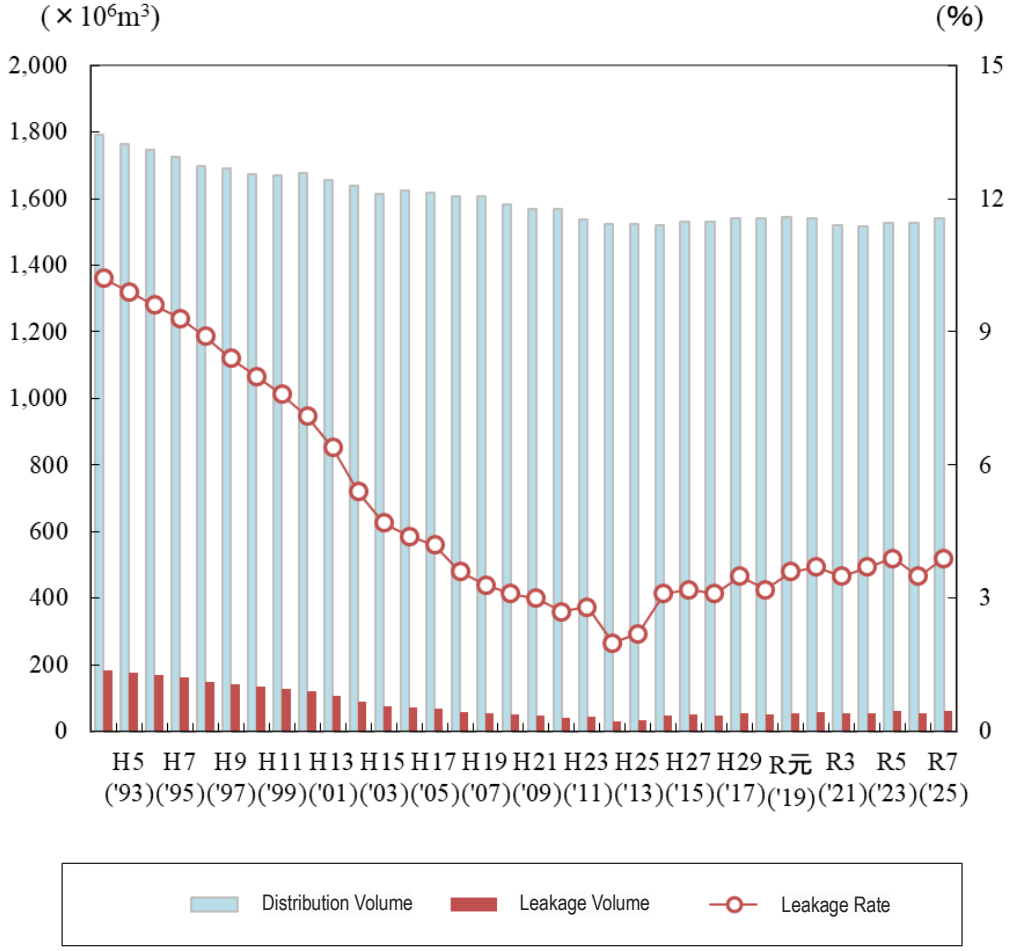
Reference 1: Analysis of Distribution Volume in FY 2025



	Water volume (m³/year)	Composition ratio (%)
Distribution volume	1,540,565,500	100.0
Effective water volume	1,478,562,725	96.0
Revenue water volume	1,472,242,411	95.6
Non-revenue water volume	6,320,314	0.4
Ineffective water volume	62,002,775	4.0
Leakage volume	59,946,448	3.9
Deduced consumption by settlement	2,056,327	0.1

* Due to rounding, the total may not always match exactly.

Reference 2: Trends in Distribution Volume, Leakage Volume, and Leakage Rate (FY 1992 to FY 2025)



		H4 ('92)	H5 ('93)	H6 ('94)	H7 ('95)	H8 ('96)	H9 ('97)	H10 ('98)	H11 ('99)	H12 ('00)	H13 ('01)
Distribution Volume	10^6m^3	1,793	1,763	1,746	1,727	1,697	1,689	1,672	1,671	1,678	1,656
Leakage Volume	10^6m^3	183	175	168	161	150	141	133	127	120	107
Leakage Rate	%	10.2	9.9	9.6	9.3	8.9	8.4	8.0	7.6	7.1	6.4

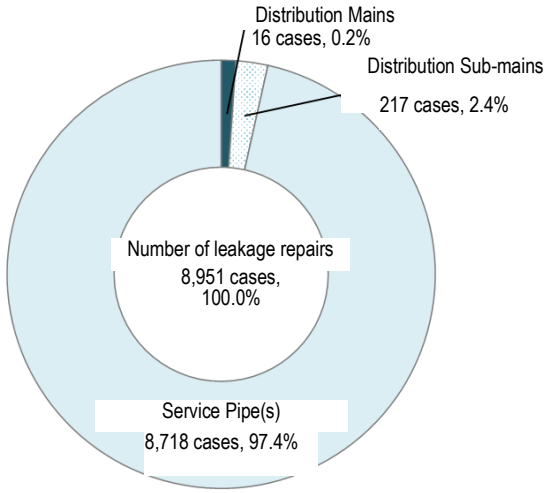
		H14 ('02)	H15 ('03)	H16 ('04)	H17 ('05)	H18 ('06)	H19 ('07)	H20 ('08)	H21 ('09)	H22 ('10)	H23 ('11)
Distribution Volume	10^6m^3	1,639	1,613	1,625	1,616	1,606	1,607	1,582	1,568	1,569	1,537
Leakage Volume	10^6m^3	89	75	72	68	58	54	50	48	42	44
Leakage Rate	%	5.4	4.7	4.4	4.2	3.6	3.3	3.1	3.0	2.7	2.8

		H24 ('12)	H25 ('13)	H26 ('14)	H27 ('15)	H28 ('16)	H29 ('17)	H30 ('18)	R元 ('19)	R2 ('20)	R3 ('21)
Distribution Volume	10^6m^3	1,523	1,523	1,521	1,530	1,530	1,542	1,541	1,543	1,541	1,521
Leakage Volume	10^6m^3	31	33	47	50	48	54	50	56	58	53
Leakage Rate	%	2.0	2.2	3.1	3.2	3.1	3.5	3.2	3.6	3.7	3.5

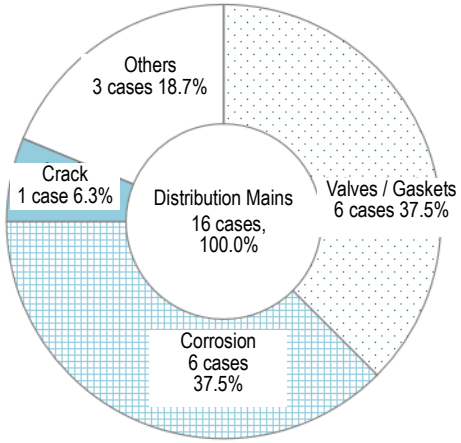
		R4 ('22)	R5 ('23)	R6 ('24)	R7 ('25)
Distribution Volume	10^6m^3	1,517	1,527	1,528	1,541
Leakage Volume	10^6m^3	56	60	53	60
Leakage Rate	%	3.7	3.9	3.5	3.9

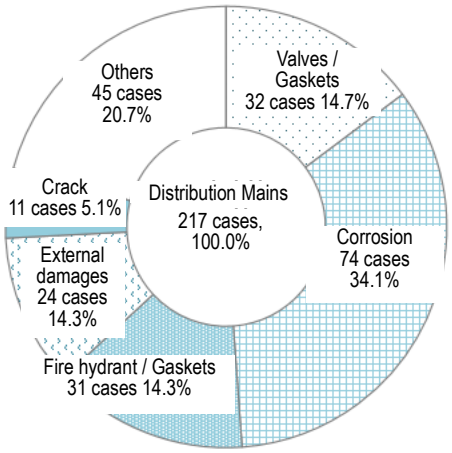
Reference 3: Ratio of Leakage Repairs in FY 2025 by Pipe Use and Cause

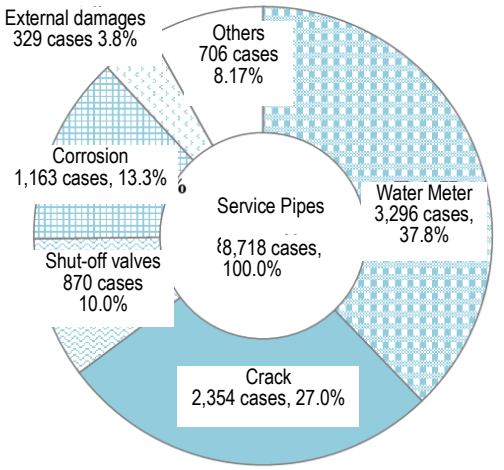
1. Ratio by Pipe Usage



2. Ratio by Cause

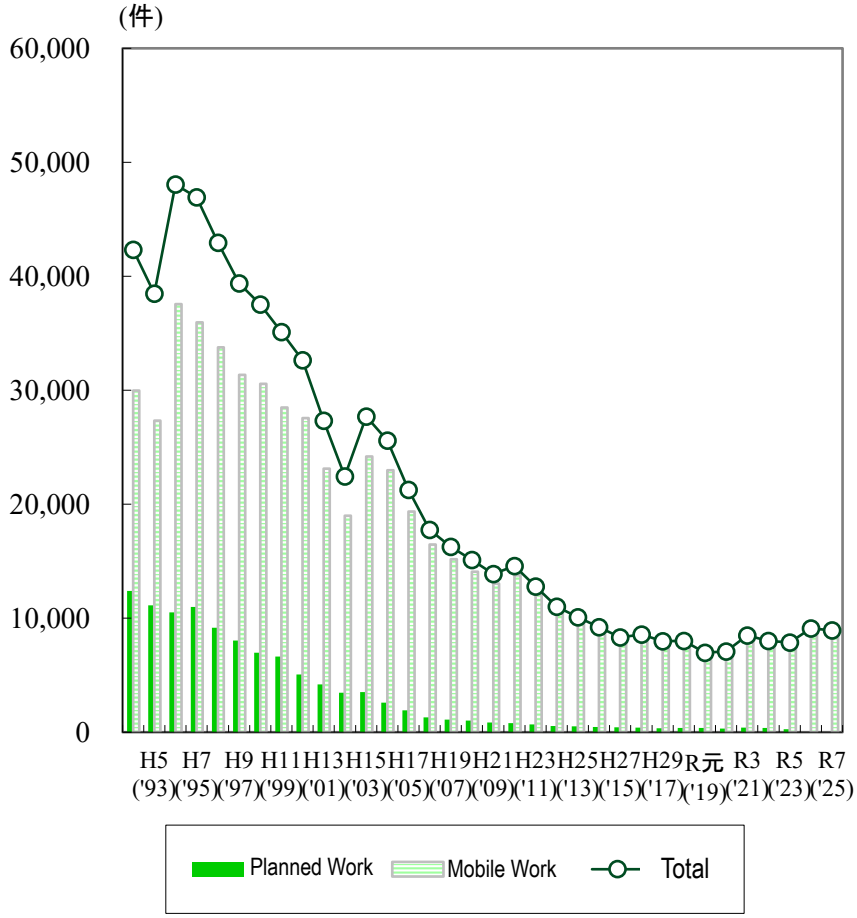






* Number of leakage repairs on service pipes, from the branch point to the water meter

Reference 4: Trends of Leakage Repairs by Type of Work (FY 1992 to FY 2025)



	H4 ('92)	H5 ('93)	H6 ('94)	H7 ('95)	H8 ('96)	H9 ('97)	H10 ('98)	H11 ('99)	H12 ('00)	H13 ('01)
Planned Work	12,383	11,142	10,505	10,979	9,177	8,028	6,964	6,627	5,073	4,199
Mobile Work	29,960	27,337	37,542	35,965	33,757	31,345	30,575	28,476	27,569	23,135
Total cases	42,343	38,479	48,047	46,944	42,934	39,373	37,539	35,103	32,642	27,334

	H14 ('02)	H15 ('03)	H16 ('04)	H17 ('05)	H18 ('06)	H19 ('07)	H20 ('08)	H21 ('09)	H22 ('10)	H23 ('11)
Planned Work	3,450	3,516	2,592	1,908	1,287	1,097	1,026	848	801	684
Mobile Work	18,996	24,186	22,987	19,361	16,460	15,173	14,083	13,046	13,777	12,090
Total cases	22,446	27,702	25,579	21,269	17,747	16,270	15,109	13,894	14,578	12,774

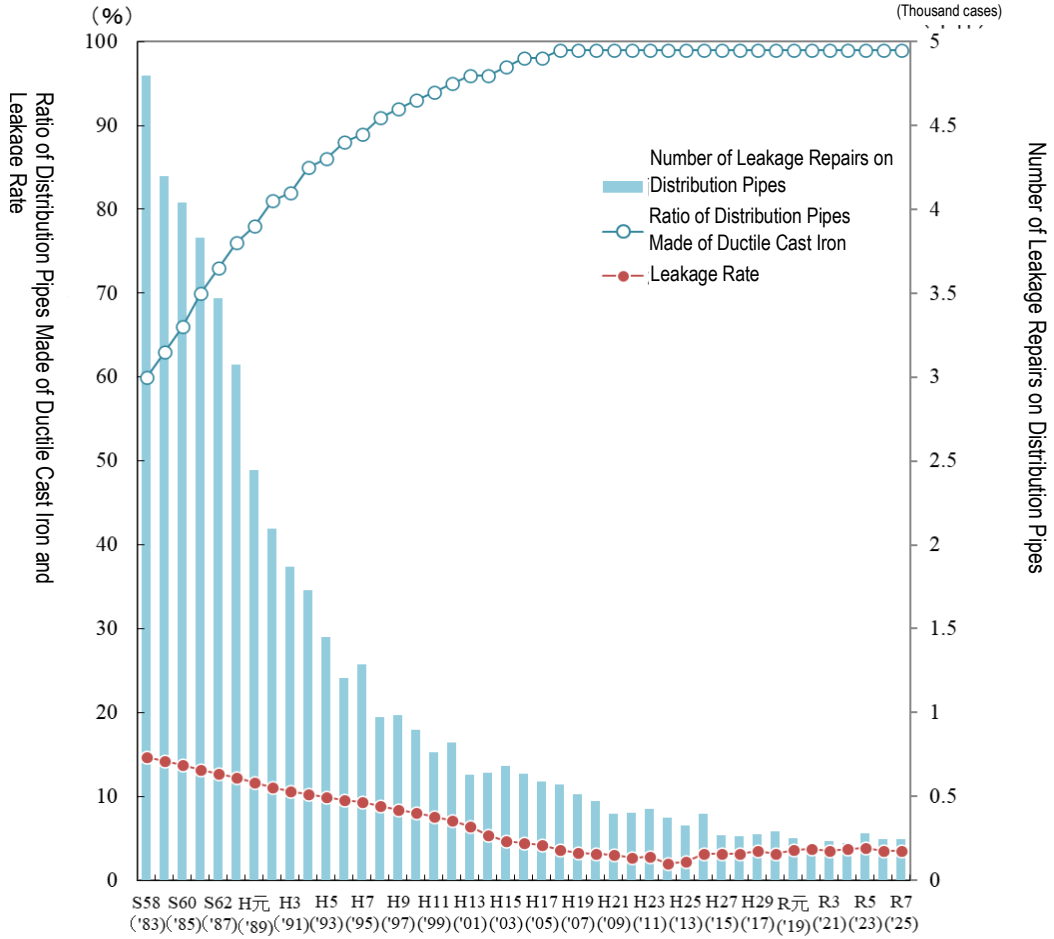
	H24 ('12)	H25 ('13)	H26 ('14)	H27 ('15)	H28 ('16)	H29 ('17)	H30 ('18)	R元 ('19)	R2 ('20)	R3 ('21)
Planned Work	542	503	454	434	403	357	383	361	306	402
Mobile Work	10,476	9,597	8,752	7,881	8,168	7,620	7,623	6,618	6,790	8,097
Total cases	11,018	10,100	9,206	8,315	8,571	7,977	8,006	6,979	7,096	8,499

	R4 ('22)	R5 ('23)	R6 ('24)	R7 ('25)
Planned Work	386	273	315	277
Mobile Work	7,628	7,612	8,802	8,674
Total cases	8,014	7,885	9,117	8,951

* From FY 2021, the calculation method for the number of leakage repair cases in the Tama district has been revised.

*1: From FY 1994, the scope of water leak repairs was expanded from “up to one meter within the property” to “up to the water meter.”
*2: From FY 2003, the target for data collection was expanded due to organizational integration

Reference 5: Trends in the Ratio of Distribution Pipes Made of Ductile Cast Iron, Leakage Repairs, and the Leakage Rate (FY 1983 to FY 2025)



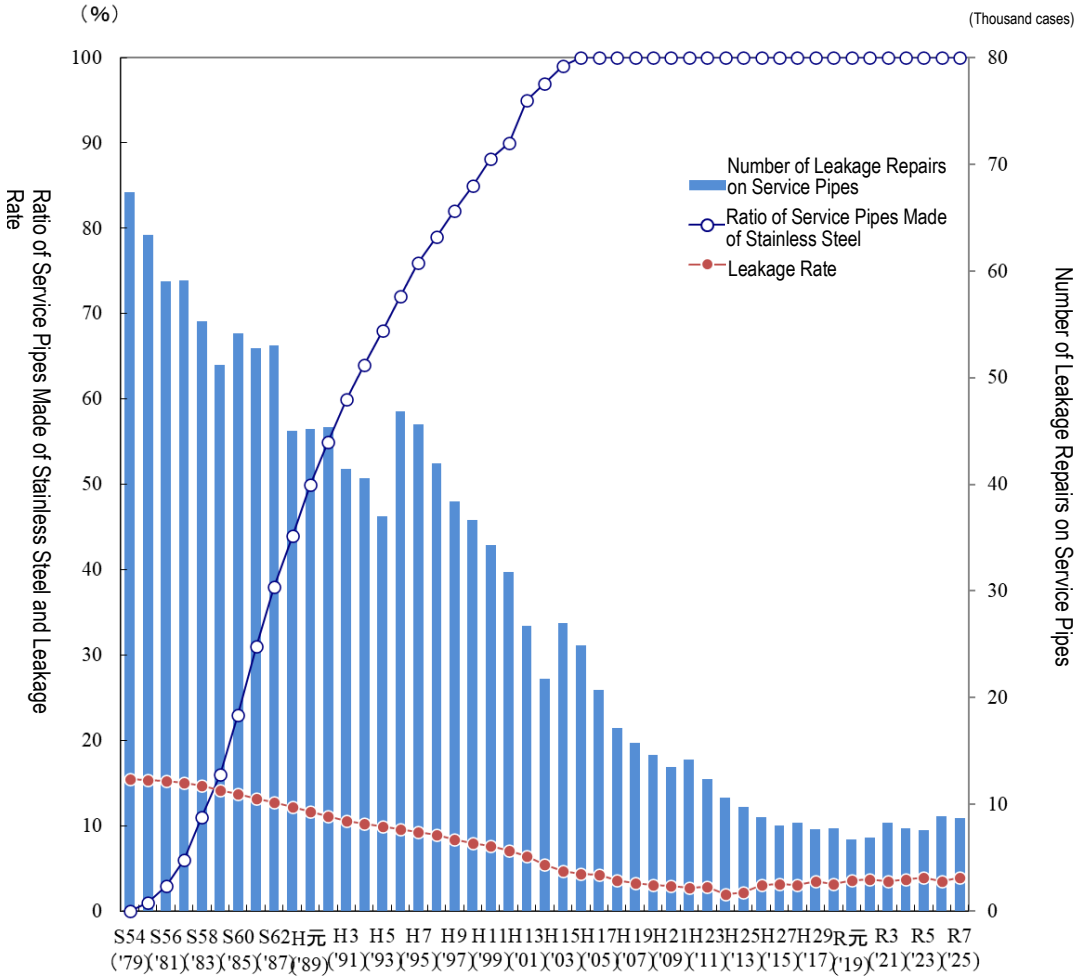
*Ratio of Distribution Pipes Made of Ductile Cast Iron :

(Until FY 2019) Ratio of ductile iron pipes in the extension of managed distribution pipes

(From FY 2020) Ratio of ductile iron pipes among cast iron pipes (standard, high-grade, and ductile)

	S58 ('83)	S59 ('84)	S60 ('85)	S61 ('86)	S62 ('87)	S63 ('88)	H元 ('89)	H2 ('90)	H3 ('91)	H4 ('92)
Ratio of Distribution pipes Made of Ductile Cast Iron (%)	60	63	66	70	73	76	78	81	82	85
Number of Leakage Repairs on Distribution Pipes (Cases)	4,800	4,200	4,040	3,834	3,471	3,072	2,447	2,097	1,870	1,730
Leakage Rate (%)	14.7	14.2	13.7	13.2	12.7	12.2	11.7	11.1	10.6	10.2
	H5 ('93)	H6 ('94)	H7 ('95)	H8 ('96)	H9 ('97)	H10 ('98)	H11 ('99)	H12 ('00)	H13 ('01)	H14 ('02)
Ratio of Distribution Pipes Made of Ductile Cast Iron (%)	86	88	89	91	92	93	94	95	96	96
Number of Leakage Repairs on Distribution Pipes (Cases)	1,449	1,205	1,288	974	987	898	762	824	627	641
Leakage Rate (%)	9.9	9.6	9.3	8.9	8.4	8.0	7.6	7.1	6.4	5.4
	H15 ('03)	H16 ('04)	H17 ('05)	H18 ('06)	H19 ('07)	H20 ('08)	H21 ('09)	H22 ('10)	H23 ('11)	H24 ('12)
Ratio of Distribution Pipes Made of Ductile Cast Iron (%)	97	98	98	99	99	99	99	99	99	99
Number of Leakage Repairs on Distribution Pipes (Cases)	679	635	587	570	511	474	399	403	424	372
Leakage Rate (%)	4.7	4.4	4.2	3.6	3.3	3.1	3.0	2.7	2.8	2.0
	H25 ('13)	H26 ('14)	H27 ('15)	H28 ('16)	H29 ('17)	H30 ('18)	R元 ('19)	R2 ('20)	R3 ('21)	R4 ('22)
Ratio of Distribution Pipes Made of Ductile Cast Iron (%)	99	99	99	99	99	99	99	99	99	99
Number of Leakage Repairs on Distribution Pipes (Cases)	326	395	270	264	275	291	252	212	235	221
Leakage Rate (%)	2.2	3.1	3.2	3.1	3.5	3.2	3.6	3.7	3.5	3.7
	R5 ('23)	R6 ('24)	R7 ('25)							
Ratio of Distribution Pipes Made of Ductile Cast Iron (%)	99	99	99							
Number of Leakage Repairs on Distribution Pipes (Cases)	278	243	233							
Leakage Rate (%)	3.9	3.5	3.9							

Reference 6: Trends in the Ratio of Service Pipes Made of Stainless Steel, Service Pipes Leakage Repairs, and Leakage Rate (FY 1979 to FY2025)



	S54 ('79)	S55 ('80)	S56 ('81)	S57 ('82)	S58 ('83)	S59 ('84)	S60 ('85)	S61 ('86)	S62 ('87)	S63 ('88)
Ratio of Service Pipes Made of Stainless Steel (%)	0	1	3	6	11	16	23	31	38	44
Number of Leakage Repairs on Service Pipes (Cases)	67,361	63,367	59,041	59,154	55,310	51,206	54,119	52,801	53,022	44,972
Leakage Rate (%)	15.5	15.4	15.2	15.0	14.7	14.2	13.7	13.2	12.7	12.2
	H元 ('89)	H2 ('90)	H3 ('91)	H4 ('92)	H5 ('93)	H6 ('94)	H7 ('95)	H8 ('96)	H9 ('97)	H10 ('98)
Ratio of Service Pipes Made of Stainless Steel (%)	50	55	60	64	68	72	76	79	82	85
Number of Leakage Repairs on Service Pipes (Cases)	45,171	45,382	41,418	40,613	37,030	46,842	45,656	41,960	38,386	36,641
Leakage Rate (%)	11.7	11.1	10.6	10.2	9.9	9.6	9.3	8.9	8.4	8.0
	H11 ('99)	H12 ('00)	H13 ('01)	H14 ('02)	H15 ('03)	H16 ('04)	H17 ('05)	H18 ('06)	H19 ('07)	H20 ('08)
Ratio of Service Pipes Made of Stainless Steel (%)	88	90	95	97	99	100	100	100	100	100
Number of Leakage Repairs on Service Pipes (Cases)	34,341	31,818	26,707	21,805	27,023	24,944	20,682	17,177	15,759	14,635
Leakage Rate (%)	7.6	7.1	6.4	5.4	4.7	4.4	4.2	3.6	3.3	3.1
	H21 ('09)	H22 ('10)	H23 ('11)	H24 ('12)	H25 ('13)	H26 ('14)	H27 ('15)	H28 ('16)	H29 ('17)	H30 ('18)
Ratio of Service Pipes Made of Stainless Steel (%)	100	100	100	100	100	100	100	100	100	100
Number of Leakage Repairs on Service Pipes (Cases)	13,495	14,175	12,350	10,646	9,774	8,811	8,045	8,307	7,702	7,715
Leakage Rate (%)	3.0	2.7	2.8	2.0	2.2	3.1	3.2	3.1	3.5	3.2
	R元 ('19)	R2 ('20)	R3 ('21)	R4 ('22)	R5 ('23)	R6 ('24)	R7 ('25)			
Ratio of Service Pipes Made of Stainless Steel (%)	100	100	100	100	100	100	100			
Number of Leakage Repairs on Service Pipes (Cases)	6,727	6,884	8,264	7,793	7,607	8,874	8,718			
Leakage Rate (%)	3.6	3.7	3.5	3.7	3.9	3.5	3.9			

*1: From FY 1994, the scope of water leak repairs was expanded from “up to 1 meter within the property” to “up to the water meter.”

*2: From FY 2003, the target for data collection was expanded due to organizational integration.

* From FY 2021, the calculation method for the number of the water leak repair cases in the Tama district has been revised.

Reference 7: Glossary of Terms for “Leakage Prevention in Tokyo”

District

Area defined by dividing the network of buried distribution sub-mains into sections of a certain extension.

Gate valve

Valves installed in pipes to shut off the flow of water (water shut-off) and regulate water pressure (flow rate) within the pipes.

Installed at branch points in distribution mains and at crossings over rivers, and other locations.

Normally, installed at intervals of approx. 500 to 1,000 meters on main distribution mains and approx. 150 to 200 meters on distribution sub-mains.

Fire Hydrant

A hydrant installed on a distribution sub-main to supply water for firefighting in the event of a fire. It is also used for draining water from the pipeline.

Distribution Main

A main pipe (with a diameter of 400 mm or more) used to distribute water from purification plants, water supply stations, and other facilities to the service area.

Distribution Sub-main

A pipe (with a diameter of 50 mm to 350 mm) that branches off from the distribution main to connect to the service pipes leading to individual customers.

Distribution Pipe

A general term for distribution main and distribution sub-main

Drain Valve

A valve used to flush out foreign matter (such as rust) from the pipes after plumbing work is completed. It serves the same function as a fire hydrant.

District meter

An accessory for a distribution sub-main consisting of a single-outlet fire hydrant and a gate valve. It is used during planned works to measure the nighttime minimum flow measurement.

Cast Iron Pipe

Cast iron pipes made of gray cast iron (tensile strength: 12.5 N/mm²). These were used until around the year 1933.

High-Grade Cast Iron Pipe

A cast iron pipe with enhanced tensile strength (25 N/mm²) by improving the manufacturing process for gray cast iron. It has been in use since around the year 1933.

Ductile Cast Iron Pipe

A cast iron pipe (tensile strength: 45 N/mm²) enhanced strength achieved by adding magnesium to conventional cast iron and spheroidizing the graphite in the microstructure. It has been used for distribution sub-mains since around the year 1967.

Early Ductile Cast Iron Pipe

A general term for pipes on a route that contain a mix of straight pipes made of ductile cast iron and special-shaped pipes made of high-grade cast iron.

Difficult-to-Replace Pipe

Non-ductile Iron pipes and older steel pipes remaining in areas where underground utilities converge or at intersections with heavy traffic.

Seismic-Resistant Joint Structure

A joint structure with a pull-out prevention function.